with its dense vegetation, its glaciers, and its unsuitability for agriculture; the desert climate of the 'dead heart' of Australia, a great barren waste, without hope of any general reclamation or development; the modified tropical climate of the plateau of East Africa, with its possibilities for future white settlement; the continental climate of central Europe, neither as extreme as that of the northern interior of North America on the one hand nor as mild and even tempered as that of the British Isles on the other."—*A. J. H.* 629.132.1 (961.3)

*Pilot-balloon observations at Apia, Samoa.*—Mr. Andrew Thomson, director of Apia Observatory, has recently published the results of 380 pilot-balloon observations made at Apia, western Samoa (lat. 13° 48.4′ S.; long. 171° 46.5′ W.), during the period between May, 1923, and April, 1928.[1] An excellent feature of the pamphlet is the numerous graphs depicting various phases of the aerological data. Especially interesting among these are Figure 3, showing the variation of wind velocity with height and the number observations at different heights; Figure 5, showing the percentage frequency of wind direction at various levels; Figures 9 and 10, showing average altitude of boundary between winds with east-west and north-south components, respectively, and Figure 11, showing the constancy of wind direction at various levels.

In connection with the change of wind direction with height the author states:

> At the surface and up to a level of 0.25 kilometers the observed winds are from nearly true east all the year round. * * * At heights from 2 to 3 kilometers westerly winds become increasingly frequent, and at 8 kilometers, they are more common than easterly winds. Above this and up to at least 14 kilometers blows a strong steady wind from approximately southwest. From March to October this wind persists to an altitude of 20 kilometers.

Regarding the velocity and constancy of upper winds he states:

> The trade winds would appear to have their maximum velocity of 6.1 m.p.s. at about 0.25 kilometers altitude, decreasing continuously above this level. In the layer of westerly winds or counter trades the maximum velocity of 10.8 m.p.s. is reached at 11.5 kilometers. G. M. B. Dobson has shown that in England the tropopause is characterized by high and rapidly varying wind velocities. It is probable that the tropopause in the latitude of Apia is at least 14 kilometers high so that the maximum velocity here found for this station is not associated with the tropopause.

In view of the fact that the average wind velocities continue to increase with height aobve 14 kilometers and also that a month's series of sounding balloon observations made at Groesbeck, Tex. (lat. 31° 30′ N.; long. 96° 28′ W.), in October, 1927,[2] showed the mean height of the stratosphere to be 14.8 kilometers it is thought that its average height over Apia is appreciably greater, probably close to 17 kilometers.[3]

Regarding the steadiness of the winds the author states:

> For the whole year the winds from the surface to 3 kilometers are steady in direction. The greatest variability occurs at 4.5 kilometers but above 6 kilometers a fairly constant direction is again maintained. This is notably the case for the stratum lying between 10 and 12 kilometers. * * * The counter trades are almost as constant at the levels where they have the greatest velocity as are the trade winds blowing at the surface.

In discussing the mass movement of air which the author represents by the product of the mean velocity and the density of the stratum, he states,

> In the layers below 14 kilometers there is 5.3 times as much air transported toward the Equator during the year as moves polewards. Every month shows this excess of northward moving air. It can scarcely be counterbalanced by currents above 14 kilometers flowing away from the Equator, since the inclusion of all available data to 20 kilometers would increase the excess. The density of air at 20 kilometers altitude is only 3 per cent of that at the surface. Since the fraction of the atmosphere above 20 kilometers which is unaccounted for is so small it must be concluded that Apia is a point where there is a great inflow of polar air toward the Equator. * * * It is probable there is almost equality in the masses of air moving eastward and westward above Apia.

It is hoped that a larger objective may be substituted for the one which was used on the theodolite in view of the author's statement that higher observations would be possible if that were done. Based on experience with the theodolites used by the Weather Bureau it is thought that heights above 20 kilometers would be comparatively frequent under the conditions of light winds prevailing in that region. It also appears probable that "free-rising" captive balloon observations would be very successful at Apia.—*L. T. Samuels.*

*Hailstorm at Duluth, Minn., June 10, 1929.*—Thunder heard at 2 p. m. and from 3 p. m. to about 4:10 p. m. Rain from 3:40 p. m. to 4:10 p. m. From 2 p. m. to 6 p. m. the barometer fell at steady rate of about 0.10 inch in four hours, no surging effect indicated by barograph. Clouds prior to storm were the usual thunderhead type. Wind force varied from moderate to fresh before, during, and after the storm—from southwest to 3:45 p. m., west to 3:56 p. m., northwest to 4:06 p. m., then west. Maximum velocity was 23 miles from northwest in the five minutes beginning 4 p. m. Very sultry conditions had prevailed all day, as well as during and immediately following the storm; this was the only outstanding or noticeable weather feature.

Hail from 3:56 p. m. to 4:07 p. m. Ground fairly carpeted with hailstones varying from marble size to as large and larger than baseballs, the larger ones being mostly round and averaging the latter size. (The standard baseball is understood to weigh 5 ounces.) The big hailstones fell between 4:05 p. m. and 4:07 p. m. The largest found at the Weather Bureau immediately after the storm measured 3 by 3 by 4¾ inches and weighed 6 ounces. Some of the irregularly shaped hail were reported as being even larger. One measured by an official of the American Paint Co. at Superior Street and Thirtieth Avenue West was stated as being 3 by 4 by 5 inches and weighing 12 ounces, and there were unauthenticated reports of still larger ones. The water content of the larger hail probably averaged around 0.02 inch. There was also some difference in weight of hail averaging the same size. Many were beautifully marked with the concentric layers.

Forty minutes after the storm a hailstone was found at the Weather Bureau measuring 2½ by 3 by 4½ inches weighing 5 ounces; and two hours after falling several were found averaging ½ by 1 by 1¾ inches and weighing around 1 ounce. The Weather Bureau lawn and flower beds are spotted with innumerable holes where the large hail fell, the holes being as deep and in some instances deeper than the measured diameter of the hail. This condition was rather general in the area affected.

As near as can be ascertained the larger hail fell over an area extending from about Fortieth Avenue East to Thirty-fifth Avenue West and northwest to including Duluth Heights, a suburb, representing a section approximately 7 miles long by 2 miles wide.

Much damage resulted, especially to store windows facing northwest, street lights, auto windows and windshields, skylights, and greenhouses. The glass damage alone will probably run about $20,000. Pelting hail stones penetrated the tops of hundreds of automobiles,

[1] Observations of Upper Currents at Apia, western Samoa (2d series), by Andrew Thomson, director of Apia Observatory. 1929.
[2] Published in this REVIEW, pp.—
[3] Nature (London), June 1, 1929, pp. 834-835, by K. R. Ramanathan.